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Big Creek Reservoir Polk County, Iowa

Pacific Northwest Environmental Research Lab, Corvallis, Oreg

Prepared for

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U.S. ENVIRONMENTAL PROTECTION AGENCY
NATIONAL EUTROPHICATION SURVEY

WORKING PAPER SERIES

CORVALLIS ENVIRONMENTAL RESEARCH LABORATORY - CORVALLIS, OREGON

and

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Report
on
Big Creek Reservoir
Polk County
Iowa
EPA Region VII
Working Paper No. 495

With the cooperation of the
Iowa Department of Environmental Quality
and the
Iowa National Guard
August, 1976

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F O R E W O R D

The National Eutrophication Survey was initiated in 1972 in response to an Administration commitment to investigate the nationwide threat of accelerated eutrophication to freshwater lakes and reservoirs.

OBJECTIVES

The Survey was designed to develop, in conjunction with state environmental agencies, information on nutrient sources, concentrations, and impact on selected freshwater lakes as a basis for formulating comprehensive and coordinated national, regional, and state management practices relating to point-source discharge reduction and non-point source pollution abatement in lake watersheds.

ANALYTIC APPROACH

The mathematical and statistical procedures selected for the Survey's eutrophication analysis are based on related concepts that:

a. A generalized representation or model relating sources, concentrations, and impacts can be constructed.

b. By applying measurements of relevant parameters associated with lake degradation, the generalized model can be transformed into an operational representation of a lake, its drainage basin, and related nutrients.

c. With such a transformation, an assessment of the potential for eutrophication control can be made.

LAKE ANALYSIS

In this report, the first stage of evaluation of lake and watershed data collected from the study lake and its drainage basin is documented. The report is formatted to provide state environmental agencies with specific information for basin planning [§303(e)], water quality criteria/standards review [§303(c)], clean lakes [§314(a,b)], and water quality monitoring [§106 and §305(b)] activities mandated by the Federal Water Pollution Control Act Amendments of 1972.

TECHNICAL REPORT DATA
(Please read Instructions on the reverse before completing)

1. REPORT NO.	2.	3. RECIPIENT'S ACCESSION NO.
4. TITLE AND SUBTITLE Report on Big Creek Reservoir, Polk County, Iowa		5. REPORT DATE Prepared August 1976 6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S) Anonymous (National Eutrophication Survey Staff)		8. PERFORMING ORGANIZATION REPORT NO. Working Paper # 495
9. PERFORMING ORGANIZATION NAME AND ADDRESS National Eutrophication Survey U.S. Environmental Protection Agency 200 S. W. 35th St. Corvallis, Oregon 97330		10. PROGRAM ELEMENT NO. 11. CONTRACT/GRANT NO.
12. SPONSORING AGENCY NAME AND ADDRESS Office of Research and Development U.S. Environmental Protection Agency 401 M Street, S. W. Washington, DC 20460		13. TYPE OF REPORT AND PERIOD COVERED Final - 1974 14. SPONSORING AGENCY CODE

15. SUPPLEMENTARY NOTES
Prepared in cooperation with the U.S. Environmental Protection Agency, National Environmental Research Center, Las Vegas, Nevada 89114

16. ABSTRACT

Annual total phosphorus and total nitrogen loadings to the lake were estimated and subdivided according to either point or non-point source origin. An assessment of the lake's trophic condition and limiting nutrient is also provided. All data collected by the U.S.E.P.A. National Eutrophication Survey during the one year study of the lake and its tributaries are included in the report.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
eutrophication lakes nutrients phosphorus nitrogen loading	PRICES SUBJECT TO CHANGE	05B 05C

18. DISTRIBUTION STATEMENT	19. SECURITY CLASS (This Report)	21. NO. OF PAGES
Release unlimited 1a	20. SECURITY CLASS (This page)	38 22. PRICE 4.00/3.00

Beyond the single lake analysis, broader based correlations between nutrient concentrations (and loading) and trophic condition are being made to advance the rationale and data base for refinement of nutrient water quality criteria for the Nation's freshwater lakes. Likewise, multivariate evaluations for the relationships between land use, nutrient export, and trophic condition, by lake class or use, are being developed to assist in the formulation of planning guidelines and policies by EPA and to augment plans implementation by the states.

ACKNOWLEDGMENT

The staff of the National Eutrophication Survey (Office of Research & Development, U. S. Environmental Protection Agency) expresses sincere appreciation to the Iowa Department of Environmental Quality for professional involvement, to the Iowa National Guard for conducting the tributary sampling phase of the Survey, and to those wastewater treatment plant operators who voluntarily provided effluent samples and flow data.

The staff of the Water Quality Division of the Department of Environmental Quality provided invaluable lake documentation and counsel during the Survey, reviewed the preliminary reports, and provided critiques most useful in the preparation of this Working Paper series.

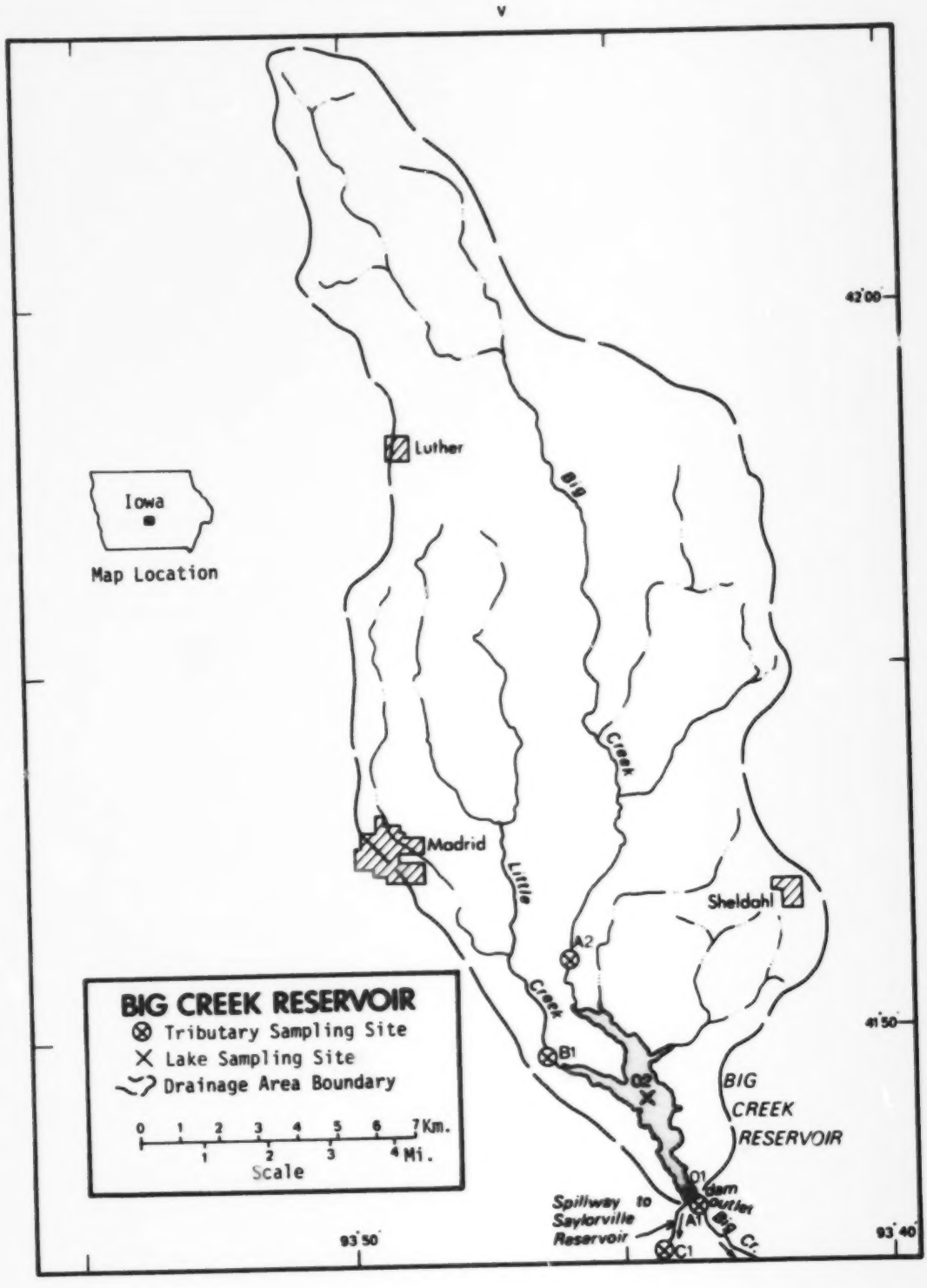
Major General Joseph G. May, the Adjutant General of Iowa, and Project Officer Colonel Cleadeth P. Woods, who directed the volunteer efforts of the Iowa National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

NATIONAL EUTROPHICATION SURVEY

STUDY LAKES

STATE OF IOWA

LAKE NAME	COUNTY
Ahquabi	Warren
Big Creek Reservoir	Polk
Black Hawk	Sac
Clear	Cerro Gordo
Darling	Washington
Lost Island	Clay, Palo Alto
MacBride	Johnson
Prairie Rose	Shelby
Rathbun Reservoir	Appanoose, Wayne
Red Rock Reservoir	Marion
Rock Creek	Jasper
Silver	Worth
Spirit	Dickinson
Viking	Montgomery
West Okoboji	Dickinson


Iowa
Map Location
Luther
Madrid
Sheldahl
Big Creek
Little Creek
BIG CREEK RESERVOIR
Tributary Sampling Site
Lake Sampling Site
Drainage Area Boundary
0 1 2 3 4 5 6 7 Km.
1 2 3 4 Mi.
Scale
A2
B1
O2
O1
dam outlet
A1
C1
Spillway to Saylorville Reservoir
Big Cr.
42°00
41°50
93°50
93°40

BIG CREEK RESERVOIR

STORET NO. 1902

I. CONCLUSIONS

A. Trophic Condition:

Survey data indicate that Big Creek Reservoir is eutrophic. It ranked ninth in overall trophic quality when the 15 Iowa lakes and reservoirs sampled in 1974 were compared using a combination of six lake parameters*. One of the water bodies had less and one had the same median total phosphorus, seven had less median orthophosphorus, all of the others had less median inorganic nitrogen, six had less mean chlorophyll a, and three had greater mean Secchi disc transparency. Depression of dissolved oxygen with depth occurred at both stations in July.

Macrophytes reportedly occur in the shallower upper portion of the reservoir but not in the lower part (Paragamian, 1974).

B. Rate-Limiting Nutrient:

The algal assay results indicate that Big Creek Reservoir was limited by phosphorus at the time the sample was collected (09/25/74). The reservoir data indicate phosphorus limitation in April as well.

C. Nutrient Controllability:

1. Point sources--No known point sources impacted Big

* See Appendix A.

Creek Reservoir during the sampling year. All sewage from the surrounding Big Creek State Recreation Area is diverted from the reservoir (Ossian, 1976).

The reservoir phosphorus loading of 2.27 g/m^2 measured during the sampling year is almost four times that proposed by Vollenweider (Vollenweider and Dillon, 1974) as a eutrophic loading (see page 11). Most of this probably resulted from agricultural activities.

2. Non-point sources--All of the phosphorus entering the reservoir during the sampling year came from non-point sources. Nearly 45% of the load was contributed by Big Creek, about 37% by Little Creek, and about 18% by minor tributaries and immediate drainage.

II. LAKE AND DRAINAGE BASIN CHARACTERISTICS†

A. Lake Morphometry††:

1. Surface area: 3.44 kilometers^2.
2. Mean depth: 6.7 meters.
3. Maximum depth: 15.5 meters.
4. Volume: 23.048 x 10^6 m^3.
5. Mean hydraulic retention time: 269 days.

B. Tributary and Outlet:
(See Appendix C for flow data)

1. Tributaries -

Name	Drainage area (km^2)*	Mean flow (m^3/sec)*
Big Creek	104.6	0.51
Little Creek	53.9	0.26
Minor tributaries & immediate drainage -	41.7	0.22
Totals	200.2	0.99

2. Outlets -

Big Creek and Spillway to Saylorville Reservoir, combined.	203.6**	.0.99

C. Precipitation***:

1. Year of sampling: 73.0 centimeters.
2. Mean annual: 78.4 centimeters.

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† Table of metric conversions--Appendix B.
†† Harrison, 1975.
* For limits of accuracy, see Working Paper No. 175, "...Survey Methods, 1973-1976".
** Includes area of reservoir.
*** See Working Paper No. 175.

III. LAKE WATER QUALITY SUMMARY

Big Creek Reservoir was sampled three times during the open-water season of 1974 by means of a pontoon-equipped Huey helicopter. Each time, samples for physical and chemical parameters were collected from a number of depths at two stations on the reservoir (see map, page v). During each visit, a single depth-integrated (4.6 m to surface) sample was composited from the stations for phytoplankton identification and enumeration; and during the last visit, a single 18.9-liter depth-integrated sample was composited for algal assays. Also each time, a depth-integrated sample was collected from each of the stations for chlorophyll a analysis. The maximum depths sampled were 15.2 meters at station 1 and 7.6 meters at station 2.

The sampling results are presented in full in Appendix D and are summarized in the following table (the July nutrient samples were not preserved properly and were not analyzed).

A. SUMMARY OF PHYSICAL AND CHEMICAL CHARACTERISTICS FOR BIG CREEK RESERVOIR
STORET CODE 1902

PARAMETER	1ST SAMPLING (4/18/74) 2 SITES RANGE	MEAN	MEDIAN	2ND SAMPLING (7/ 9/74) 2 SITES RANGE	MEAN	MEDIAN	3RD SAMPLING (9/25/74) 2 SITES RANGE	MEAN	MEDIAN
TEMP (C)	7.8 - 11.8	9.8	9.8	13.2 - 26.7	22.5	24.3	16.9 - 18.1	17.4	17.4
DISS OXY (MG/L)	9.8 - 16.4	12.8	11.4	0.2 - 8.0	6.0	7.4	6.6 - 9.2	7.8	7.7
CNDCTVY (MCROMU)	252. - 439.	352.	381.	507. - 630.	582.	590.	440. - 450.	440.	448.
PH (STAND UNITS)	8.3 - 8.5	8.4	8.5	7.8 - 8.4	8.1	8.3	7.7 - 7.9	7.8	7.8
TOT ALK (MG/L)	298. - 388.	328.	328.	------ ----------			226. - 258.	242.	241.
TOT P (MG/L)	0.059 - 0.105	0.075	0.075	------ ----------			0.024 - 0.033	0.028	0.029
ORTHO P (MG/L)	0.013 - 0.049	0.029	0.027	------ ----------			0.006 - 0.010	0.007	0.007
NO2+NO3 (MG/L)	5.740 - 7.590	6.739	6.745	------ ----------			5.320 - 7.440	6.031	5.795
AMMONIA (MG/L)	0.020 - 0.170	0.071	0.060	------ ----------			0.070 - 0.120	0.095	0.095
KJEL N (MG/L)	0.500 - 1.100	0.712	0.700	------ ----------			0.400 - 0.600	0.450	0.400
INORG N (MG/L)	5.860 - 7.610	6.810	6.830	------ ----------			5.430 - 7.510	6.126	5.855
TOTAL N (MG/L)	6.340 - 8.090	7.451	7.480	------ ----------			5.720 - 7.840	6.481	6.235
CHLRPYL A (UG/L)	26.0 - 42.0	34.0	34.0	2.7 - 12.8	7.7	7.7	8.4 - 9.3	8.8	8.8
SECCHI (METERS)	0.8 - 1.1	0.9	0.9	1.2 - 1.2	1.2	1.2	2.4 - 2.6	2.5	2.5

B. Biological characteristics:

1. Phytoplankton -

Sampling Date	Dominant Genera	Algal Units per ml
04/18/74	1. *Stephanodiscus sp.*	14,887
	2. Flagellates	665
	3. *Ankistrodesmus sp.*	250
	4. *Chlamydomonas sp.*	208
	5. *Gymnodinium sp.*	166
	Other genera	416
	Total	16,592
07/09/74	1. *Asterionella sp.*	595
	2. *Stephanodiscus sp.*	457
	3. Flagellates	46
	Total	1,098
09/25/74	1. *Melosira sp.*	1,167
	2. *Fragilaria sp.*	257
	3. *Stephanodiscus sp.*	40
	4. *Aphanizomenon sp.*	40
	5. *Aphanothece sp.*	40
	Other genera	117
	Total	1,661

2. Chlorophyll *a* -

Sampling Date	Station Number	Chlorophyll *a* (µg/l)
04/18/74	1	42.0
	2	26.0
07/09/74	1	12.8
	2	2.7
09/25/74	1	8.4
	2	9.3

C. Limiting Nutrient Study:

1. Autoclaved, filtered, and nutrient spiked -

Spike (mg/l)	Ortho P Conc. (mg/l)	Inorganic N Conc. (mg/l)	Maximum yield (mg/l-dry wt.)
Control	0.005	5.070	0.1
0.050 P	0.055	5.070	3.3
0.050 P + 1.0 N	0.055	6.070	3.5
1.0 N	0.005	6.070	0.1

2. Discussion -

The control yield of the assay alga, Selenastrum capricornutum, indicates that the potential primary productivity of Big Creek Reservoir was low at the time the assay sample was collected (09/25/74). Also, a significant increase in yield with the addition of phosphorus alone indicates that the lake was limited by phosphorus at that time. Note that the addition of nitrogen alone resulted in a yield identical to that of the control.

The reservoir data indicate phosphorus limitation in April as well as in September (the mean inorganic nitrogen to orthophosphorus ratios were 235 to 1 and 875 to 1, respectively).

IV. NUTRIENT LOADINGS
(See Appendix E for data)

For the determination of nutrient loadings, the Iowa National Guard collected monthly near-surface grab samples from each of the tributary sites indicated on the map (page v), except for the high runoff period from May through July when samples were collected approximately every two weeks. Sampling was begun in August, 1974, and was completed in July, 1975.

Through an interagency agreement, stream flow estimates for the year of sampling and a "normalized" or average year were provided by the Iowa District Office of the U.S. Geological Survey for the tributary sites nearest the reservoir.

In this report, nutrient loads for sampled streams were determined using a modification of a U.S. Geological Survey computer program for calculating stream loadings*. The combined outlet loads are based on nutrient concentrations measured at the Big Creek outlet (A-1), but nutrient data for both outlets are included in Appendix E. Nutrient loads shown are those measured minus point-source loads, if any.

Nutrient loads for unsampled "minor tributaries and immediate drainage" ("ZZ" of U.S.G.S.) were estimated using the nutrient loads at station A-2, in $kg/km^2/year$, and multiplying by the ZZ area in km^2.

No known point sources impacted Big Creek Reservoir during the sampling year.

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* See Working Paper No. 175.

A. Waste Sources:

1. Known municipal - None

2. Known industrial - None

B. Annual Total Phosphorus Loading - Average Year:

1. Inputs -

Source	kg P/ yr	% of total
a. Tributaries (non-point load) -		
Big Creek	3,485	44.7
Little Creek	2,880	36.9
b. Minor tributaries & immediate drainage (non-point load) -	1,375	17.6
c. Known municipal STP's - None	-	-
d. Septic tanks - None	-	-
e. Known industrial - None	-	-
f. Direct precipitation* -	60	0.8
Total	7,800	100.0

2. Outputs -

Lake outlets - Big Creek and Spillway	2,055

3. Net annual P accumulation - 5,745 kg.

* See Working Paper No. 175.

C. Annual Total Nitrogen Loading - Average Year:

1. Inputs -

Source	kg N/yr	% of total
a. Tributaries (non-point load) -		
Big Creek	186,220	50.4
Little Creek	105,050	28.5
b. Minor tributaries & immediate drainage (non-point load) -	74,225	20.1
c. Known municipal STP's - None	-	-
d. Septic tanks - None	-	-
e. Known industrial - None	-	-
f. Direct precipitation* -	3,715	1.0
Total	369,210	100.0

2. Outputs -

Lake outlets - Big Creek and Spillway	201,830

3. Net annual N accumulation - 167,380 kg.

D. Non-point Nutrient Export by Subdrainage Area:

Tributary	kg P/km^2/yr	kg N/km^2/yr
Big Creek	33	1,780
Little Creek	53	1,949

* See Working Paper No. 175.

E. Yearly Loads:

In the following table, the existing phosphorus loadings are compared to those proposed by Vollenweider (Vollenweider and Dillon, 1974). Essentially, his "dangerous" loading is one at which the receiving water would become eutrophic or remain eutrophic; his "permissible" loading is that which would result in the receiving water remaining oligotrophic or becoming oligotrophic if morphometry permitted. A mesotrophic loading would be considered one between "dangerous" and "permissible".

Note that Vollenweider's model may not be applicable to water bodies with short hydraulic retention times.

	Total Phosphorus		Total Nitrogen	
	Total	Accumulated	Total	Accumulated
grams/m^2/yr	2.27	1.67	107.3	48.7

Vollenweider phosphorus loadings ($g/m^2/yr$) based on mean depth and mean hydraulic retention time of Big Creek Reservoir:

"Dangerous" (eutrophic loading)	0.58
"Permissible" (oligotrophic loading)	0.29

V. LITERATURE REVIEWED

Ossian, Roger (Recreation Area Officer), 1976. Personal communication (State Recreation Area sewage disposal system). Big Creek Reservoir State Recreation Area, Polk City.

Harrison, Harry M., 1975. Personal communication (reservoir morphometry). IA Cons. Comm., Des Moines.

Paragamian, Vaughn L., 1974. Man-made lake investigations. Fed. Aid to Fish Rest. Proj. No. F-88-R-1, IA Cons. Comm., Des Moines.

Vollenweider, R. A., and P. J. Dillon, 1974. The application of the phosphorus loading concept to eutrophication research. Natl. Res. Council of Canada Publ. No. 13690, Canada Centre for Inland Waters, Burlington, Ontario.

VI. APPENDICES

APPENDIX A

LAKE RANKINGS

LAKE DATA TO BE USED IN RANKINGS

LAKE CODE	LAKE NAME	MEDIAN TOTAL P	MEDIAN INORG N	500-MEAN SEC	MEAN CHLORA	15-MIN DO	MEDIAN DISS ORTHO P
1901	LAKE ACQUABI	0.062	0.335	469.333	8.600	8.200	0.009
1902	BIG CREEK RESERVOIR	0.046	6.465	438.500	16.867	14.800	0.011
1903	BLACK HAWK LAKE	0.185	0.130	488.167	49.740	15.000	0.020
1904	CLEAR LAKE	0.059	0.070	465.125	17.400	8.600	0.010
1905	LAKE DARLING	0.077	1.475	482.500	13.817	9.200	0.012
1906	LOST ISLAND LAKE	0.146	0.065	421.167	36.100	8.400	0.021
1907	LAKE MACBRIDE	0.061	2.035	458.444	17.067	15.000	0.010
1908	PRAIRIE ROSE LAKE	0.056	0.210	463.667	17.350	8.600	0.010
1909	RATHBUN RESERVOIR	0.071	1.170	475.889	12.039	14.000	0.008
1910	RED ROCK LAKE	0.180	1.880	473.400	14.730	14.000	0.104
1911	ROCK CREEK LAKE	0.065	1.400	480.500	18.367	8.400	0.007
1912	SILVER LAKE	0.193	0.565	482.667	95.380	10.000	0.034
1913	SPIRIT LAKE	0.041	0.090	422.667	12.622	9.000	0.007
1914	VIKING LAKE	0.075	0.130	459.000	26.033	14.200	0.017
1915	WEST LAKE OKOBOJI	0.046	0.060	380.444	7.722	15.000	0.017

PERCENT OF LAKES WITH HIGHER VALUES (NUMBER OF LAKES WITH HIGHER VALUES)

LAKE CODE	LAKE NAME	MEDIAN TOTAL P	MEDIAN INORG N	500-MEAN SEC	MEAN CHLORA	15-MIN DO	MEDIAN DISS ORTHO P	INDEX NO
1901	LAKE ACQUABI	57 (8)	50 (7)	43 (6)	93 (13)	100 (14)	79 (11)	422
1902	BIG CREEK RESERVOIR	89 (12)	0 (0)	79 (11)	57 (8)	21 (3)	50 (7)	296
1903	BLACK HAWK LAKE	7 (1)	68 (9)	0 (0)	7 (1)	7 (0)	21 (3)	110
1904	CLEAR LAKE	71 (10)	86 (12)	50 (7)	36 (5)	75 (10)	64 (8)	382
1905	LAKE DARLING	29 (4)	21 (3)	14 (2)	71 (10)	57 (8)	43 (6)	235
1906	LOST ISLAND LAKE	21 (3)	93 (13)	93 (13)	14 (2)	89 (12)	14 (2)	324
1907	LAKE MACBRIDE	64 (9)	7 (1)	71 (10)	50 (7)	7 (0)	64 (8)	263
1908	PRAIRIE ROSE LAKE	79 (11)	57 (8)	57 (8)	43 (6)	75 (10)	64 (8)	375
1909	RATHBUN RESERVOIR	43 (6)	36 (5)	29 (4)	86 (12)	39 (5)	86 (12)	319
1910	RED ROCK LAKE	14 (2)	14 (2)	36 (5)	64 (9)	39 (5)	0 (0)	167
1911	ROCK CREEK LAKE	50 (7)	29 (4)	21 (3)	29 (4)	89 (12)	96 (13)	314
1912	SILVER LAKE	0 (0)	43 (6)	7 (1)	0 (0)	50 (7)	7 (1)	107
1913	SPIRIT LAKE	100 (14)	79 (11)	86 (12)	79 (11)	64 (9)	96 (13)	504
1914	VIKING LAKE	36 (5)	68 (9)	64 (9)	21 (3)	29 (4)	32 (4)	250
1915	WEST LAKE OKOBOJI	89 (12)	100 (14)	100 (14)	100 (14)	7 (0)	32 (4)	428

LAKES RANKED BY INDEX NOS.

RANK	LAKE CODE	LAKE NAME	INDEX NO
1	1913	SPIRIT LAKE	504
2	1915	WEST LAKE OKOBOJI	428
3	1901	LAKE ACQUABI	422
4	1904	CLEAR LAKE	382
5	1908	PRAIRIE ROSE LAKE	375
6	1906	LOST ISLAND LAKE	324
7	1909	RATHBUN RESERVOIR	319
8	1911	ROCK CREEK LAKE	314
9	1902	BIG CREEK RESERVOIR	296
10	1907	LAKE MACBRIDE	263
11	1914	VIKING LAKE	250
12	1905	LAKE DARLING	235
13	1910	RED ROCK LAKE	167
14	1903	BLACK HAWK LAKE	110
15	1912	SILVER LAKE	107

APPENDIX B

CONVERSION FACTORS

CONVERSION FACTORS

Hectares x 2.471 = acres

Kilometers x 0.6214 = miles

Meters x 3.281 = feet

Cubic meters x 8.107×10^{-4} = acre/feet

Square kilometers x 0.3861 = square miles

Cubic meters/sec x 35.315 = cubic feet/sec

Centimeters x 0.3937 = inches

Kilograms x 2.205 = pounds

Kilograms/square kilometer x 5.711 = lbs/square mile

APPENDIX C

TRIBUTARY FLOW DATA

TRIBUTARY FLOW INFORMATION FOR IOWA 02/05/76

LAKE CODE 1902 BF CREEK RES.

TOTAL DRAINAGE AREA OF LAKE(SQ KM) 203.6

TRIBUTARY	SUB-DRAINAGE AREA(SQ KM)	NORMALIZED FLOWS(CMS) JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN
1902A1	203.6	0.31	0.75	1.58	1.38	1.22	1.23	0.88	0.49	1.61	1.06	0.88	0.43	0.99
1902A2	104.6	0.16	0.39	0.81	0.71	0.63	0.63	0.45	0.25	0.83	0.55	0.45	0.22	0.51
1902B1	53.9	0.08	0.20	0.42	0.37	0.32	0.33	0.23	0.13	0.43	0.28	0.23	0.11	0.26
1902Z2	45.1	0.07	0.17	0.35	0.31	0.27	0.27	0.18	0.11	0.36	0.24	0.20	0.10	0.22

SUMMARY

TOTAL DRAINAGE AREA OF LAKE = 203.6
SUM OF SUB-DRAINAGE AREAS = 203.6
TOTAL FLOW IN = 11.82
TOTAL FLOW OUT = 11.84

NOTE *** C1 NORMALIZED FLOWS INCLUDED IN A1 .

MEAN MONTHLY FLOWS AND DAILY FLOWS(CMS)

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
1902A1	8	74	0.03	17	0.03				
	9	74	0.05	24	0.05				
	10	74	0.04	24	0.04				
	11	74	0.04	23	0.04				
	12	74	0.03	23	0.03				
	1	75	0.03	27	0.03				
	2	75	0.03	20	0.03				
	3	75	0.04						
	4	75	0.06	28	0.06				
	5	75	0.06	10	0.06	19	0.06	31	0.06
	6	75	0.04	20	0.04				
	7	75	0.03	18	0.03				
1902A2	8	74	0.07	17	0.08				
	9	74	0.06	24	0.03				
	10	74	0.05	24	0.02				
	11	74	0.12	23	0.07				
	12	74	0.11	23	0.10				
	1	75	0.10	27	0.07				
	2	75	0.07	20	0.07				
	3	75	0.91						
	4	75	1.22	28	2.21				
	5	75	0.62	10	0.59	19	0.42	31	1.08
	6	75	2.07	20	1.64				
	7	75	0.42	18	0.20				

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TRIBUTARY FLOW INFORMATION FOR IOWA 02/05/76

LAKE CODE 1902 BIG CREEK RES.

MEAN MONTHLY FLOWS AND DAILY FLOWS(CMS)

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
1902B1	8	74	0.04	17	0.06				
	9	74	0.03	24	0.01				
	10	74	0.02	24	0.01				
	11	74	0.06	23	0.03				
	12	74	0.05	23	0.05				
	1	75	0.05	27	0.04				
	2	75	0.04	20	0.03				
	3	75	0.48						
	4	75	0.62	28	1.13				
	5	75	0.34	10	0.31	19	0.23	31	0.54
	6	75	1.08	20	0.85				
	7	75	0.22	18	0.10				
1902C1	8	74	0.0	17	0.0				
	9	74	0.0	24	0.0				
	10	74	0.0	24	0.0				
	11	74	0.0	23	0.0				
	12	74	0.0	23	0.0				
	1	75	0.0	27	0.0				
	2	75	0.0	20	0.0				
	3	75	1.73						
	4	75	2.29	28	4.22				
	5	75	1.19	10	1.10	19	0.79	31	2.01
	6	75	3.57	20	2.83				
	7	75	0.71	18	0.34				
1902Z2	8	74	0.03						
	9	74	0.03						
	10	74	0.02						
	11	74	0.05						
	12	74	0.05						
	1	75	0.04						
	2	75	0.03						
	3	75	0.40						
	4	75	0.51						
	5	75	0.27						
	6	75	0.91						
	7	75	0.18						

APPENDIX D

PHYSICAL and CHEMICAL DATA

STORET RETRIEVAL DATE 75/12/23

190201
42 05 24.0 094 02 54.0
BIG CREEK RESERVOIR
19015 IOWA

11EPALES
3

2111202
0055 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00610 NH3-N TOTAL MG/L	00625 TOT KJEL N MG/L	00630 NO2&NO3 N-TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P
74/04/18	15	40 0000	11.8		43	252	8.50	290	0.030	0.800	6.980	0.013
	15	40 0005	11.1	16.4		319	8.40	290	0.050	0.700	6.590	0.020
	15	40 0015	9.8	14.2		381	8.30	325	0.080	0.600	7.270	0.035
	15	40 0025	8.7	11.4		406	8.30	330	0.170	0.700	6.900	0.049
	15	40 0050	7.8	9.8		439	8.40	320	0.030	1.100	6.260	0.014
74/07/09	10	10 0000	25.1	7.8	48	610	8.40					
	10	10 0005	24.9	7.8		600	8.40					
	10	10 0015	24.3	7.4		590	8.30					
	10	10 0025	19.5	4.8		507	7.80					
	10	10 0050	13.2	0.2		560	7.80					
74/09/25	13	35 0000	17.6	8.0	96	448	7.74	232	0.120	0.600	5.950	0.007
	13	35 0005	17.4	7.4		448	7.74	242	0.120	0.400	5.730	0.007
	13	35 0019	17.4	7.2		448	7.72	240	0.120	0.500	5.690	0.010
	13	35 0038	17.3	7.2		447	7.73	226	0.110	0.400	5.320	0.008

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L	00031 INCDT LT REMNING PERCENT
74/04/18	15	40 0000	0.059	42.0	
	15	40 0005	0.072		
	15	40 0015	0.065		
	15	40 0025	0.059		
	15	40 0050	0.105		
74/07/09	10	10 0000		12.8	
74/09/25	13	35 0000	0.029	8.4	
	13	35 0002			50.0
	13	35 0005	0.026		
	13	35 0019	0.029		1.0
	13	35 0038	0.033		

STORET RETRIEVAL DATE 75/12/23

190202
42 05 24.0 094 02 54.0
BIG CREEK RESERVOIR
19015 IOWA

11EPALES 2111202
3 0030 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00610 NH3-N TOTAL MG/L	00625 TOT KJEL N MG/L	00630 NO2&NO3 N-TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P
74/04/18	16	05 0000	11.2		30	255	8.50					
	16	05 0005	10.3	15.4		310	8.50	340	0.070	0.700	6.580	0.039
	16	05 0015	9.2	11.4		391	8.50	380	0.120	0.600	5.740	0.045
	16	05 0025	8.0	10.8		414	8.50	350	0.020	0.500	7.590	0.020
74/07/09	10	45 0000	26.7	8.0	48	630	8.40					
	10	45 0005	26.4	8.0		623	8.30					
	10	45 0015	23.3	6.0		586	8.10					
	10	45 0025	19.5	3.6		531	7.80					
74/09/25	14	10 0000	18.1	9.2	104	450	7.91	258	0.080	0.500	5.780	0.006
	14	10 0005	17.6	6.6		444	7.90	248	0.070	0.400	7.440	0.007
	14	10 0017	17.1	8.4		441	7.90	252	0.070	0.400	5.650	0.006
	14	10 0025	16.9	8.6		440	7.89	234	0.070	0.400	6.690	0.009

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L	00031 INCDT LT REMNING PERCENT
74/04/18	16	05 0000		26.0	
	16	05 0005	0.083		
	16	05 0015	0.078		
	16	05 0025	0.081		
74/07/09	10	45 0000		2.7	
74/09/25	14	10 0000	0.024	9.3	
	14	10 0003			50.0
	14	10 0005	0.029		
	14	10 0017	0.026		1.0
	14	10 0025	0.030		

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APPENDIX E

TRIBUTARY DATA

STORET RETRIEVAL DATE 76/01/27

1902A1
41 47 40.0 093 43 00.0
BIG CREEK
19 7.5 SLATER
O/BIG CREEK RESERVOIR
BELO DAM SPLLWAY 1.5 MI N OF POLK CITY
11EPALES 2111204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
74/09/24	15 40		3.400	0.900	0.010	0.025	0.070
74/11/25	14 30		4.100	0.600	0.100	0.010	0.030
74/12/23	11 05		4.600	0.600	0.095	0.050	0.060
75/01/27	15 25		5.040	0.700	0.144	0.040	0.050
75/02/20	15 30		5.280	0.600	0.144	0.088	0.100
75/04/28	11 35		4.600	0.700	0.035	0.020	0.050
75/05/10	19 40		4.730	1.200	0.140	0.035	0.050
75/05/19	10 55		4.400	1.250	0.195	0.020	0.030
75/05/31	17 20		4.300	0.500	0.210	0.010	0.120
75/06/20	09 50		4.300	1.500	0.360	0.045	0.110
75/07/18	10 05		4.400	1.500	0.590	0.120	0.130
75/07/31	10 40		4.000	1.600	0.710	0.140	0.180

STORET RETRIEVAL DATE 76/02/09

1902A2
41 50 55.0 093 46 00.0
BIG CREEK
19153 7.5 GRANGER
T/BIG CREEK RESERVOIR
LGHT DTY RD BRDG 2.75 MI SE OF MADRID
11EPALES 2111204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P	50051 FLOW RATE INST MGD	50053 CONDUIT FLOW-MGD MONTHLY
74/08/17	15 05		4.400	1.300	0.115	0.120	0.260		
74/09/24	10 55		0.128	0.700	0.015	0.010	0.055		
74/10/24	12 50		0.024	0.700	0.025	0.005	0.025		
74/11/23	14 30		6.750	0.400	0.035	0.035	0.060		
74/12/23	10 20		6.780	0.700	0.030	0.045	0.080		
75/04/28	11 05		7.200	0.550	0.045	0.130	0.180		
75/05/10	19 15		10.000	1.400	0.065	0.060	0.210		
75/05/19	10 25		9.600	1.350	0.060	0.025	0.170		
75/05/31	16 45		11.500	1.600	0.035	0.080	0.320		
75/06/20	09 25		10.500	1.900	0.035	0.108	0.500		
75/07/18	09 40		11.000	0.550	0.015	0.020	0.040		
75/07/31	10 15		4.900	0.750	0.030	0.015	0.050		

STORET RETRIEVAL DATE 76/01/27

190281
41 49 40.0 093 46 20.0
LITTLE CREEK
19 7.5 GRANGER
T/BIG CREEK RESERVOIR
LGHT DTY RD BRDG 4.5 MI SE OF MADRID
11EPALES 2111204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
74/08/17	14	33	3.800	1.000	0.075	0.055	0.155
74/09/24	15	15	0.024	1.900	0.025	0.030	0.210
74/10/24	12	45	0.008	1.000	0.030	0.050	0.115
74/11/23	14	20	5.680	0.900	0.050	0.210	0.290
74/12/23	10	45	7.130	0.600	0.060	0.100	0.150
75/01/27	15	10	6.900	1.300	0.400	0.180	0.230
75/02/20	15	10	6.300	1.300	0.352	0.184	0.230
75/04/28	11	20	9.200	4.500	0.103	0.133	1.500
75/05/10	19	30	11.000	0.925	0.050	0.080	0.140
75/05/19	10	35	10.500	1.400	0.025	0.030	0.170
75/05/31	17	05	12.600	1.600	0.050	0.085	0.290
75/06/20	09	40	10.500	1.850	0.030	0.115	0.440
75/07/18	09	50	12.000	0.750	0.030	0.055	0.100
75/07/31	10	20	6.000	1.100	0.065	0.025	0.110

STORET RETRIEVAL DATE 76/01/27

1902C1
41 47 10.0 093 43 15.0
BIG CREEK
19153 15 SLATER
0/BIG CREEK RESERVOIR
20 FT BELOW BIG CREEK DAM SPILLWAY
11EPALES 2111204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
74/08/17	16 00		6.200	0.800	0.060	0.015	0.035
74/09/24	14 55		0.439	1.800	0.162	0.020	0.120
74/11/23	14 15		3.830	0.700	0.128	0.010	0.030
74/12/23	11 20		4.270	0.500	0.070	0.020	0.020
75/01/27	15 40		3.800	0.800	0.088	0.015	0.030
75/02/20	15 50		3.900	0.900	0.056	0.024	0.050
75/04/28	11 50		4.900	0.750	0.025	0.025	0.160
75/05/10	19 50		5.400	0.900	0.020	0.005	0.020
75/05/19	11 10		5.200	1.750	0.045	0.010	0.150
75/05/31	17 30		5.200	1.100	0.060	0.015	0.070
75/06/20	11 20		6.900	1.100	0.135	0.030	0.115
75/07/18	10 25		7.600	0.900	0.090	0.005	0.030
75/07/31	11 00		4.950	1.300	0.250	0.005	0.070